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EOSDIS Core System Project

Release B Availability Models/Predictions for the ECS Project

March 1996

Hughes Information Technology Systems
Upper Marlboro, Maryland

Release B Availability Models/Predictions for the ECS Project

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SUBMITTED BY

R. E. Clinard /s/ 3/29/96

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EOSDIS Core System Project

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Preface

This document is a contract deliverable with an approval code 2. As such, it does not require formal Government approval, however, the Government reserves the right to request changes within 45 days of the initial submittal. Once approved, contractor changes to this document are handled in accordance with Class I and Class II change control requirements described in the EOS Configuration Management Plan, and changes to this document shall be made by document change notice (DCN) or by complete revision.

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Abstract

This Availability Models/Predictions report (CDRL 88, DID 515) presents the analytical results of the ECS required functional availabilities. These functional availabilities are calculated based on detailed hardware configurations presented at the Science Data Processing (SDPS)/ Communications and Systems Management (CSMS) Segments Release B Critical Design Review (CDR). The functional availability results of the Flight Operations Segment (FOS) remain unchanged since the last submittal of this report at the FOS Critical Design Review (CDR) time frame. The models in this document use mean-time-between-failure (MTBF) and mean-time-to-repair (MTTR) inputs from the Reliability Predictions Report (CDRL 89, DID 516) and the Maintainability Predictions Report (CDRL 91, DID 518) respectively.

Keywords: Availability, models, prediction, mean time between maintenance (MTBM), mean-time-between-failure (MTBF), mean time to repair (MTTR), mean down time (MDT), switchover time (ST), redundant, duty cycle.

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Abbreviations and Acronyms

1. Introduction

1.1 Identification

This Availability Models/Predictions Report, Contract Data Requirements List (CDRL) item 088, whose requirements are specified in Data Item Description (DID) 515/PA2, is a required deliverable under the Earth Observing System Data and Information System (EOSDIS) Core System (ECS), Contract (NAS5-60000).

1.2 Scope

This report incorporates Government's comments received by the Data Management Office (DMO) on December 6, 1995 in technical report No. 995-TR-951-175. This report also provides updates to the Release B Incremental Design Review (IDR) submittal which was generated at the ECS Release B IDR time frame. The purpose of this submittal is to reflect the current ECS architecture and to present detailed assessments of the ECS and its functions operational availabilities (A_o) and Mean Down Time (MDT) as stated in the Functional and Performance Requirements Specification for the ECS project, 423-41-02. These assessments were based on analytical predictions and probabilistic determination of the ECS Hardware Configuration Items (HWCIs) as presented at the Release B Critical Design Review (CDR) time frame. These HWCIs represent the Flight Operations Segment (FOS) Release A/B configuration, the Science and Data Processing Segment (SDPS) and the Communications and Systems Management Segment (CSMS) Release B CDR configuration. FOS Release A/B is only applied to the GSFC site. Since this submittal is only applicable to the SDPS/CSMS Release B CDR configuration, the FOS section remains unchanged from the previous submittal.

The SDPS and CSMS functional availability calculations are Distributed Active Archive Center (DAAC) site specific. The applicable Distributed Active Archive Center (DAAC) sites for the Release B CDR for SDPS and CSMS are: Goddard Space Flight Center (GSFC), Earth Resources Observation System (EROS) Data Center (EDC), Langley Research Center (LaRC), Jet Propulsion Laboratory (JPL), National Snow and Ice Data Center (NSIDC), Oak Ridge National Laboratory (ORNL), and Alaska Synthetic Aperture Radar (SAR) Facility (ASF).

The availability modeling effort includes the development of hardware functional and reliability block diagrams or strings for each Segment and function of the ECS. Mathematical models were developed for each block diagram with the underlying ground rules and assumptions. The ECS availability models have been implemented on Excel 5.0 workbooks. These models consist of a series of linked workbooks and workbook pages that accept user's inputs, calculate individual equipment/subsystem availability, estimate overall functional availability, display the results in graphical and tabulated formats, and allow the exercise of "what-if" scenarios. This modeling process is described in detail in Section 7.0 of the report.

Analytical results for each required RMA functional string are provided in spreadsheet and graphical formats in Appendix A. The data required to perform the availability analyses were obtained from both the ECS Reliability and Maintainability Predictions reports, documents 516-CD-002-002 and 518-CD-002-002, respectively.

This document reflects the February 1996 Technical Baseline maintained by the contractor configuration control board in accordance with the ECS Technical Direction No.11, dated 12/06/1994.

1.3 Purpose and Objectives

The purpose of this document is to present mathematical models and techniques applied by the ECS contractor to analytically demonstrate compliance with the ECS Functional and Performance Requirements Specification for all required functional availabilities. The modeling results are expressed in terms of Mean Time Between Maintenance (MTBM), Mean Down Time (MDT), and operational availability (A_O). The system availability modeling effort was initiated early in the ECS design phase and will continue throughout the operational phase to analyze effects of design changes occurring as a result of sustaining engineering activity, maintenance activities, or aging. Availability models will be updated with information resulting from reliability/maintainability predictions as well as design or operational changes (including any changes in mission parameters or operational constraints).

1.4 Document Status and Schedule

This submittal of DID 515/PA2 meets the milestone specified in the Contract Data Requirements List (CDRL) of NASA contract NAS5-60000. It is anticipated that this submittal will be reviewed during the Release B Critical Design Review (CDR), and that subsequent changes to the document will be incorporated into a resubmittal to be delivered two weeks after receiving comments from the customer.

Subsequent availability models/predictions updates for each release configuration will be submitted at each release Incremental Design Review (IDR), CDR, and throughout the ECS life cycle.

1.5 Document Organization

The document is organized into eight (8) sections and two appendices:

Section 1	Introduction, contains the identification, scope, purpose and objectives, status and schedule, and document organization.
Section 2	Related Documents, provides a bibliography of parent, applicable and information documents for the Availability Models/Predictions.
Section 3	ECS System Description, provides a brief ECS System overview and each Segment Hardware Architecture description.

Section 4	ECS Functional Availability Requirements, summarizes the ECS System Level as well as the Segment Level availability requirements.
Section 5	ECS RMA Functional Descriptions and Block Diagrams, describes each Segment functional availability requirement and their associated reliability block diagrams.
Section 6	ECS Availability Math Models and RMA Data Sources, describes the math models and the source of the RMA data to support the availability modeling effort.
Section 7	ECS RMA Modeling Process, describes the modeling process using Excel 5.0 workbooks with ground rules and assumptions that the models are based on.
Section 8	Summary of ECS Availability Results, presents the summary of all required functional availabilities by operational DAAC sites.
Appendix A	Availability Data Worksheets and Analytical Results, provides a complete set of Excel spreadsheets, reliability block diagrams and their availability/ mean down time results for all required RMA functions.

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2. Related Documentation

2.1 Parent Documents

The parent document is the document from which this Availability Models/Predictions document scope and content are derived.

194-207-SE1-001	Systems Design Specification for the ECS Project
420-05-03	Goddard Space Flight Center, Earth Observing System (EOS) Performance Assurance Requirements for the EOSDIS Core System (ECS)
423-41-01	Goddard Space Flight Center, EOSDIS Core System (ECS) Statement of Work
423-41-02	Goddard Space Flight Center, Functional and Performance Requirements Specification for the Earth Observing System Data and Information System (EOSDIS) Core System
423-41-03	Goddard Space Flight Center, EOSDIS Core System (ECS) Contract Data Requirements Document

2.2 Applicable Documents

The following documents are referenced within this Availability Models/Predictions document, or are directly applicable, or contain policies or other directive matters that are binding upon the content of this volume.

194-501-PA1-001	Performance Assurance Implementation Plan (PAIP) for the ECS Project
194-502-PA1-001	Contractor's Practices & Procedures Referenced in the PAIP for the ECS Project
516-CD-002-002	Reliability Predictions for the ECS Project
518-CD-002-002	Maintainability Predictions for the ECS Project
210-TP-001-006	Technical Baseline for the ECS Project
NPRD-91	Reliability Analysis Center, Rome Laboratory, Griffiss AFB, Nonelectronic Parts Reliability Data, 1991

2.3 Information Documents

The following documents, although not referenced herein and/or not directly applicable, do amplify or clarify the information presented in this document. These documents are not binding on the content of the Availability Models/Predictions document.

305-CD-001-002 & 311-CD-001-002	Flight Operations Segment (FOS) Design Specification and FOS Database Design and Database Schema Specifications, Final
305-CD-020-002	Release B SDPS/CSMS Design Specification Overview
305-CD-023-002	Release B SDPS Data Management Subsystem Design Specification for the ECS Project
305-CD-024-002	Release B SDPS Data Server Subsystem Design Specification for the ECS Project
305-CD-025-002	Release B SDPS Ingest Subsystem Design Specification for the ECS Project
305-CD-026-002	Release B SDPS Planning Subsystem Design Specification for the ECS Project
305-CD-027-002	Release B SDPS Data Processing Subsystem Design Specification for the ECS Project
305-CD-028-002	Release B CSMS Communication Subsystem Design Specification for the ECS Project
613-CD-002-001	Release A COTS Maintenance Plan for the ECS Project
MIL-STD-756	Military Standard: Reliability Modeling and Prediction
MIL-STD-785	Military Standard: Reliability Program For Systems and Equipment Development and Production, Task 201

3. ECS System Description

3.1 ECS Overview

The EOSDIS Core System (ECS) is the major component of the EOS Data and Information System (EOSDIS). The ECS will control the EOS spacecraft and instruments, process data from the EOS instruments, and manage and distribute EOS data products and other selected data sets. Interoperating with other data systems maintained by government agencies and the research community, the ECS will provide comprehensive services for accessing Earth science data.

A goal of the ECS program is to provide a highly adaptable system that is responsive to the evolving needs of the Earth science community. Thus, the ECS will support the "vision" of an evolving and comprehensive information system to promote effective utilization of data for research in support of the Mission to Planet Earth (MTPE) goals.

The Earth Observing System includes NASA instruments on satellites to be launched by NASA, the European Space Agency (ESA), and the Japanese National Space Agency (NASDA). Figure 3.1-1 presents a view of the EOS Mission Components. Figure 3.1-2, EOS Mission Science Dataflow, provides a view of the flow of science data from these various platforms to the users. The ECS consists of the shaded portions of Figure 3.1-2, plus facilities for operation of the NASA EOS satellites and instruments, including NASA instruments on International Partner satellites. For a detailed description of these data flows, refer to the System Design Specification for the ECS Project, 194-207-SE1-001.

ECS is composed of three segments defined to support three major operational areas: flight operations, science data processing, and communications/system management. The following sections provide a brief description of these ECS segments.

3.2 FOS Description

The Flight Operations Segment (FOS) manages and controls the EOS spacecraft and instruments. The FOS is responsible for mission planning, scheduling, control, monitoring, and analysis in support of mission operations for U.S. EOS spacecraft and instruments. The FOS also provides investigator-site ECS software (the Instrument Support Terminal (IST) tool kit) to connect a Principal Investigator (PI) or Team Leader (TL) facility to the FOS in remote support of instrument control and monitoring. PI/TL facilities are outside the FOS, but connected to it by way of the EBNet. The FOS focuses on the command and control of the flight segment of EOS and the interaction with ECS ground operations. For detail description of the FOS architecture, refer to the FOS Design Specification, document 305-CD-002-002. Figure 3.2-1 provides a block diagram of the FOS system architecture, which includes the FOS computers, networks, and peripherals.

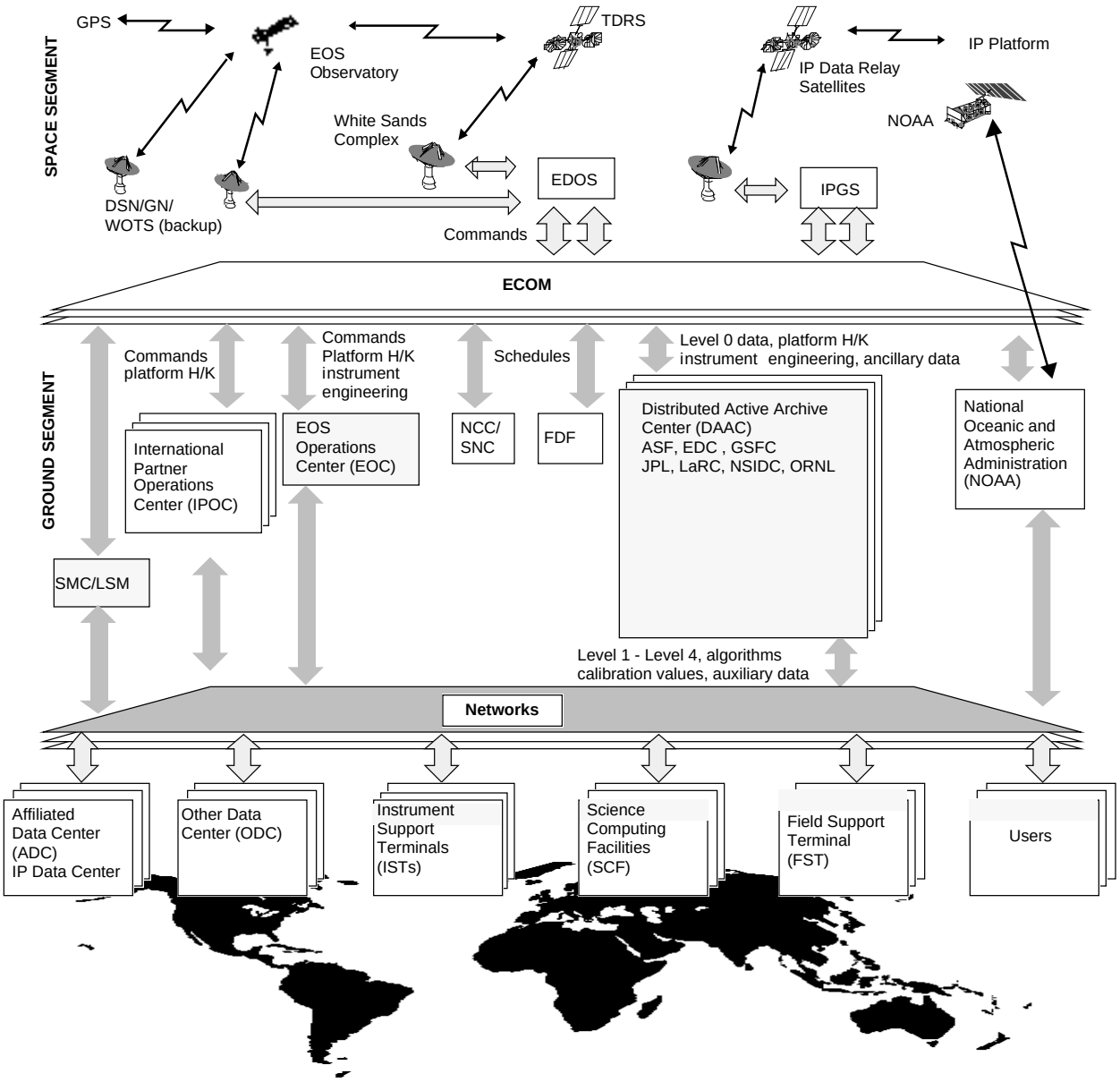

Figure 3.1-1. EOS Mission Components

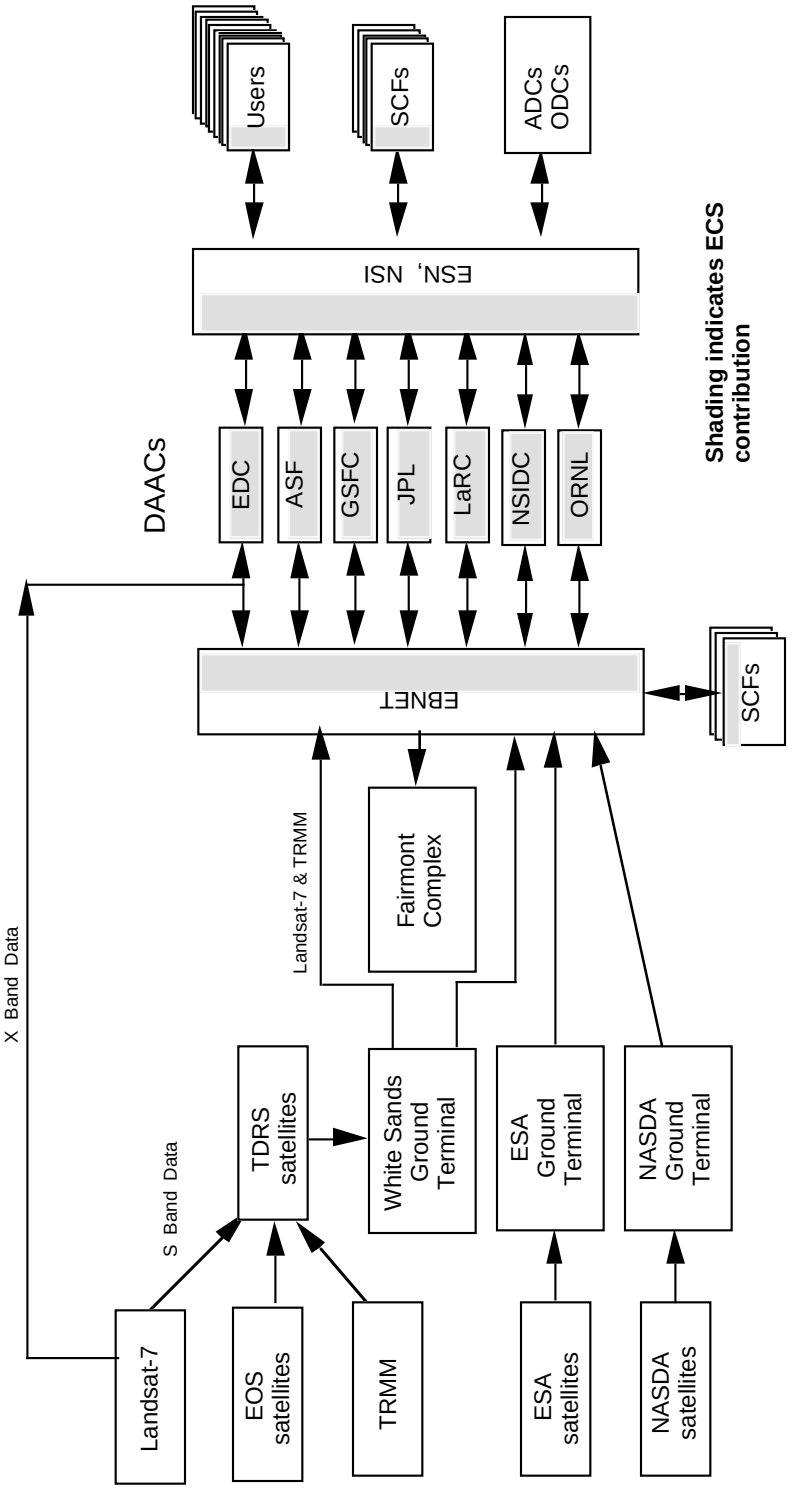

Figure 3.1-2. EOS Mission Science Dataflow

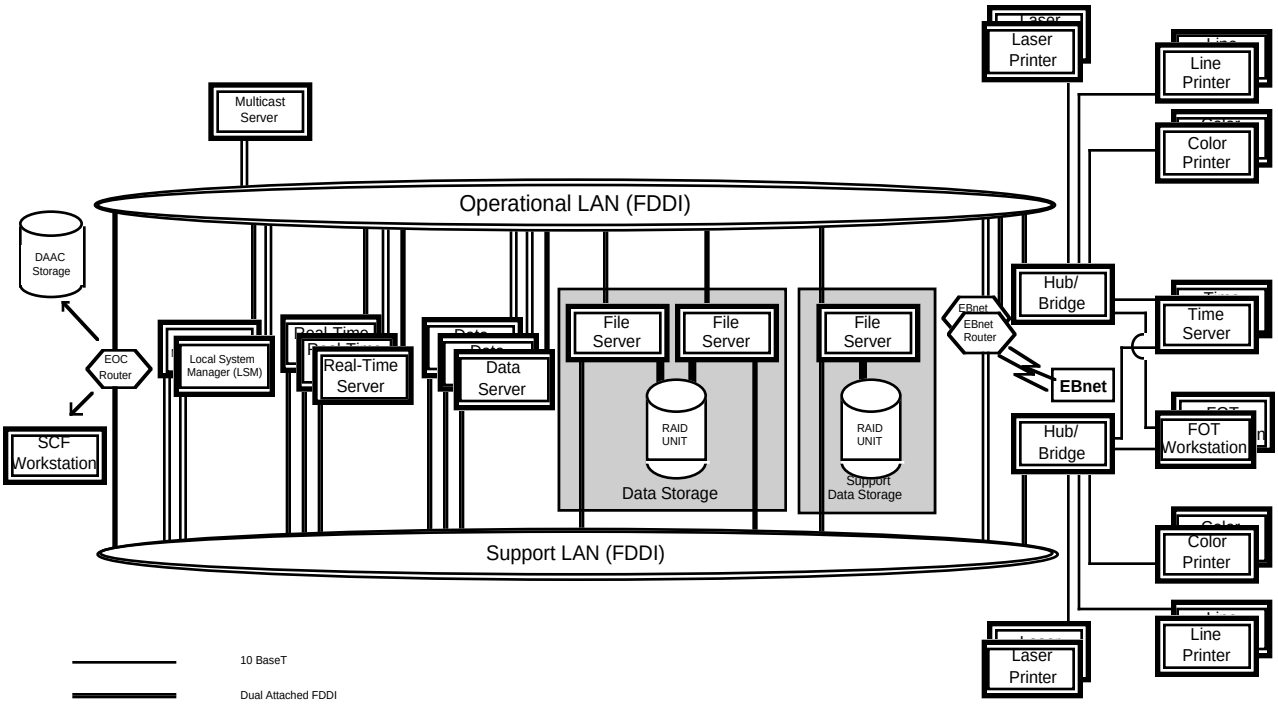

Figure 3.2-1. FOS System Architecture

3.3 SDPS Description

The Science Data Processing Segment (SDPS) receives, processes, archives and manages all data from EOS and other NASA Probe flight missions. It provides support to the user community in accessing the data as well as products resulting from research activities that utilize this data. SDPS also promotes, through advertisement services, the effective utilization and exchange of data within the user community. Finally, the SDPS plays a central role in providing the science community with the proper infrastructure for development, experimental usage and quality checking of new Earth science algorithms. SDPS is a distributed system and its components are currently located at seven Distributed Active Archive Centers (DAACs). For detail description of the SDPS architecture, refer to the SDPS/CSMS Design Overview, document 305-CD-020-002. Figure 3.3-1 presents a representative SDPS/CSMS Release B CDR hardware topology for the LaRC DAAC.

3.4 CSMS Description

The Communications and System Management Segment (CSMS) focuses on the system components involved with the interconnection of user and service providers and with system management of the ECS components. The CSMS is composed of three major Subsystems. They are the Communications Subsystem (CSS), the Internetworking Subsystem (ISS), and System

Management Subsystem (MSS). The MSS, which includes several decentralized Local System Management capabilities at the DAAC sites and the mission operation center, provides system management services for the EOS ground system resources. The services provided by the MSS, even though they rely on the CSS provided services, are largely allocable to the application domain. For detail description of the CSMS architecture, refer to the SDPS/CSMS Design Overview, document 305-CD-020-001. Figure 3.3-1 presents a representative SDPS/CSMS Release B CDR hardware topology for the LaRC DAAC.

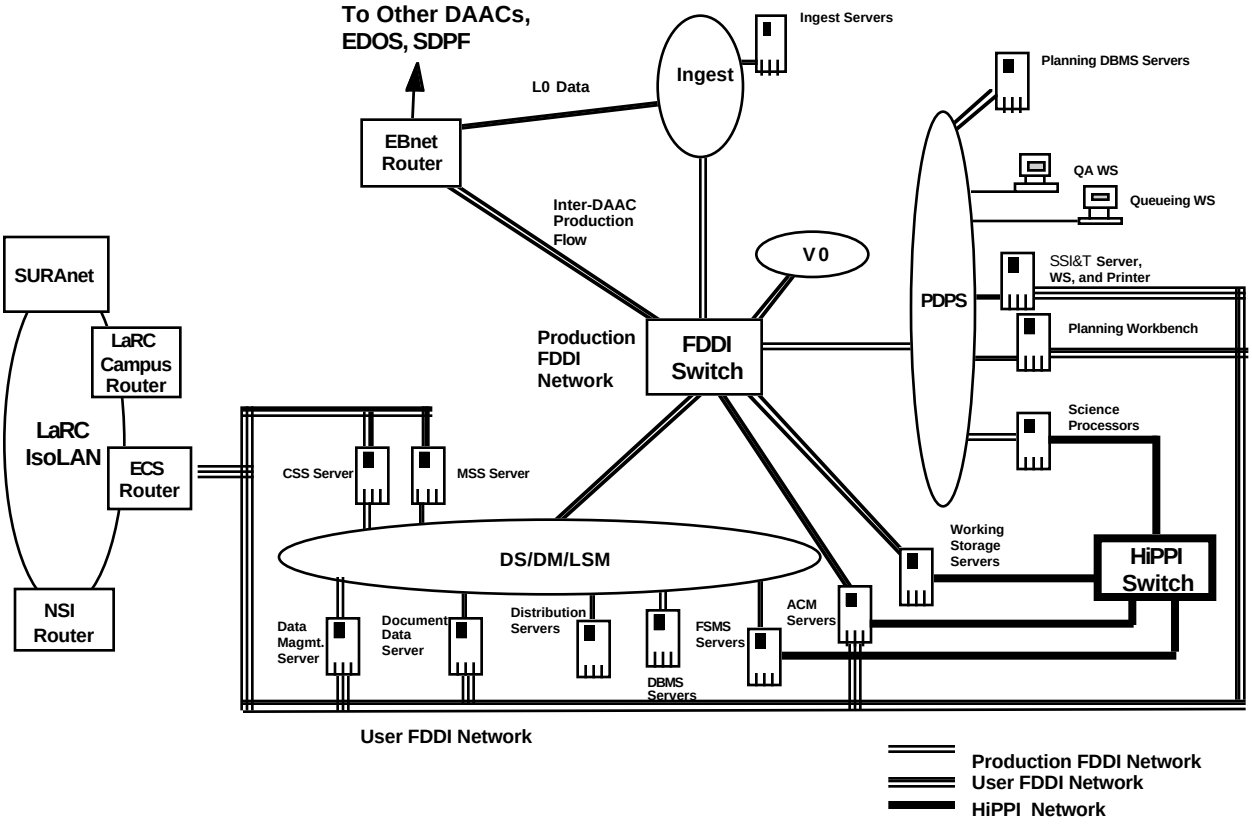

Figure 3.3-1. Release B LaRC SDPS/CSMS Hardware Topology

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4. ECS Functional Availability Requirements

4.1 System-Level Availability Requirements

The ECS System-level quantitative availability requirement is as follows:

EOSD3700 ECS functions shall have an operational availability of 0.96 at a minimum and an MDT of four (4) hours or less, unless otherwise specified.

The above requirement covers equipment including:

a. "Non-critical" equipment configured with the critical equipment supporting the functional capabilities in the requirements

b. Equipment providing other functionality not explicitly stated in the following Segment-level availability requirements.

4.2 Segment-Level Availability Requirements

The following sections summarize the three Segments quantitative availability requirements of the ECS.

4.2.1 Flight Operations Segment (FOS) Availability requirements

EOSD3800 The FOS shall have an operational availability of 0.9998 at a minimum (.99997 design goal) and an MDT of one (1) minute or less (0.5 minute design goal) for critical real-time functions.

EOSD3810 The FOS shall have an operational availability of 0.99925 at a minimum (.99997 design goal) and an MDT of five (5) minutes or less (0.5 minute design goal) for non-critical real-time functions.

4.2.2 Science Data Processing Segment (SDPS) Availability Requirements

EOSD3900 The SDPS function of receiving science data shall have an operational availability of 0.999 at a minimum (.99995 design goal) and an MDT of two (2) hours or less (8 minutes design goal).

EOSD3910 The switchover time from the primary science data receipt capability to a backup capability shall be 15 minutes or less (10 minutes design goal).

EOSD3920 The SDPS function of archiving and distributing data shall have an operational availability of 0.98 at a minimum (.999999 design goal) and an MDT of two (2) hours or less (9 minutes design goal).

EOSD3930 The user interfaces to Information Management System (IMS) services at individual Distributed Active Archive Center (DAAC) sites shall have an operational availability of 0.993 at a minimum (.9997 design goal) and an MDT of two (2) hours or less (1.4 hour design goal).

EOSD3940 The SDPS function of Information Searches on the ECS Directory shall have an operational availability of 0.993 at a minimum (.9997 design goal) and an MDT of two (2) hours or less (1.4 hour design goal).

EOSD3950 The SDPS function of ASTER Instrument Data Acquisition Request (DAR) Submittal including TOOs shall have an operational availability of 0.993 at a minimum (.999999 design goal) and an MDT of two (2) hours or less (6 minutes design goal).

EOSD3960 The SDPS function of Metadata Ingest and Update shall have an operational availability of 0.96 at a minimum (.999999 design goal) and an MDT of four (4) hours or less (6 minutes design goal).

EOSD3970 The SDPS function of Information Searches on Local Holdings shall have an operational availability of 0.96 at a minimum (.999999 design goal) and an MDT of four (4) hours or less (6 minutes design goal).

EOSD3980 The SDPS function of Local Data Order Submission shall have an operational availability of 0.96 at a minimum (.999999 design goal) and an MDT of four (4) hours or less (6 minutes design goal).

EOSD3990 The SDPS function of Data Order Submission Across DAACs shall have an operational availability of 0.96 at a minimum (.999999 design goal) and an MDT of four (4) hours or less (6 minutes design goal).

EOSD4000 The SDPS function of IMS Data Base Management and Maintenance Interface shall have an operational availability of 0.96 at a minimum (.999999 design goal) and an MDT of four (4) hours or less (6 minutes design goal).

EOSD4010 Each computer providing product generation shall have an operational availability of 0.95 at a minimum (.9995 design goal).

4.2.3 Communications and System Management Segment (CSMS) Availability Requirements

EOSD4030 The SMC function of gathering and disseminating system management information shall have an operational availability of .998 at a minimum (.999998 design goal) and an MDT of 20 minutes or less (5 minutes design goal), for critical services.

EOSD4036 The operational availability of individual ESN segments shall be consistent with the specified operational availability of the supported ECS functions.